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3D elastic full waveform inversion: case study from a land seismic survey

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Full Waveform Inversion (FWI) is one of the most advanced processing methods that is recently reaching a mature state after years of solving theoretical and technical issues such as the non-uniqueness of the solution and harnessing the huge computational power required by realistic scenarios. BSIT (Barcelona Subsurface Imaging Tools, www.bsc.es/bsit) includes a FWI algorithm that can tackle with very complex problems involving large datasets.
We present here the application of this system to a 3D dataset acquired to constrain the shallow subsurface. This is where the wavefield is the most complicated, because most of the wavefield conversions takes place in the shallow region and also because the media is much more laterally heterogeneous. With this in mind, at least isotropic elastic approximation would be suitable as kernel engine for FWI. The current study explores the possibilities to apply elastic isotropic FWI using only the vertical component of the recorded seismograms.
The survey covers an area of 500×500 m^2, and consists in a receivers grid of 10 m$\times$20 m combined with a 250 kg accelerated weight-drop as source on a displaced grid of 20 m$\times$20 m. One of the main challenges in this case study is the costly 3D modeling that includes topography and substantial free surface effects. FWI is applied to a data subset (shooting lines 4 to 12), and is performed for 3 frequencies ranging from 15 to 25 Hz. The starting models are obtained from travel-time tomography and the all computation is run on 75 nodes of Mare Nostrum supercomputer during 3 days. The resulting models provide a higher resolution of the subsurface structures, and show a good correlation with the available borehole measurements. FWI allows to extend in a reliable way this 1D knowledge (borehole) to 3D.